Chemical SAFETY AND SECURITY TRAINING

Workshop

Cairo, Egypt

8 January 2009

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Sandia National Laboratories

Laboratory Chemical Safety: Concepts of Anticipation, Recognition, Evaluation and Control

Douglas B. Walters, Ph.D., CSP, CCHO

Environmental & Chemical Safety Educational Institute

Fundamentals of

Laboratory Chemical Safety

References

"Safety in Academic Laboratories, Vol.1 & 2," American Chemical Society, Washington DC, 2003, handouts and available online: http://membership.acs.org/c/ccs/publications.htm

"Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 1995, available online: http://www.nap.edu/catalog.php?record_id=4911

"Hazardous Chemicals: Control and Regulation in the European Market," H.F.Bender and P. Eisenbarth, Wiley-VCH, Weinheim Germany, 2007

Purpose of Laboratory Chemical Safety

- Protect the worker
- Safeguard the environment
- Comply with regulations
- Support the conduct of the studies

Laboratory Chemical Safety

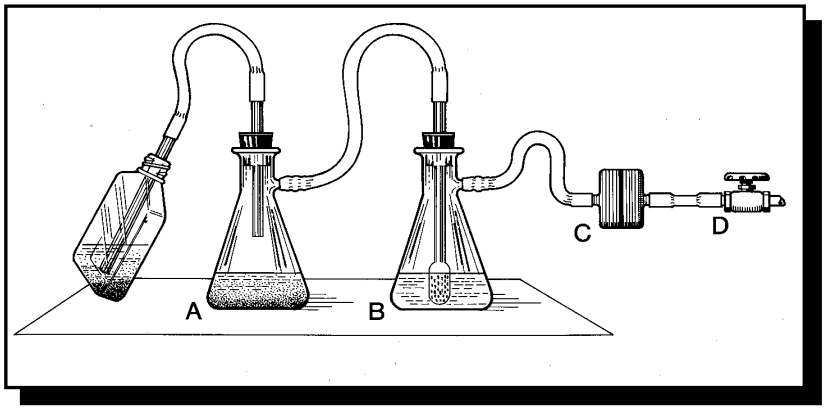
Safety---freedom from danger, injury, or property damage

Hazard---the potential to harm

Risk---the probability that harm will result

Laboratory Chemical Safety

Are all agents dangerous?



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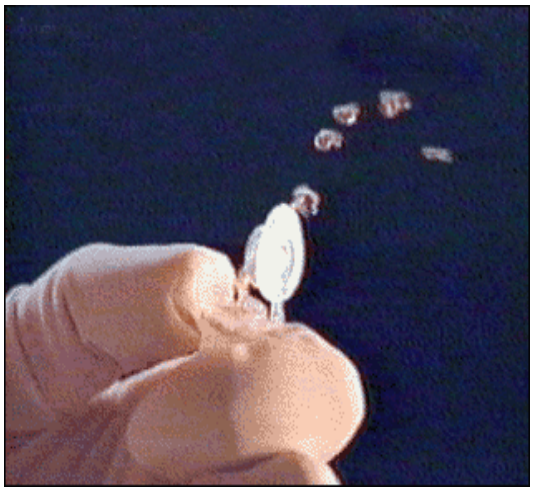
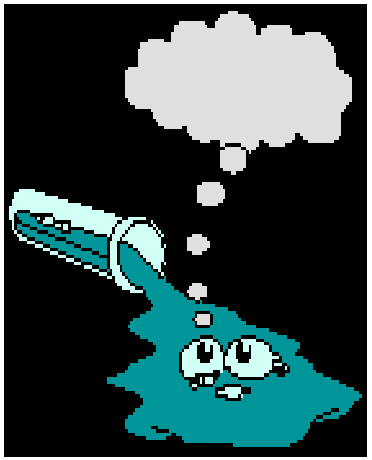


Is it their *improper* use that makes them dangerous?

Degree of hazard depends on

- Chemical / physical properties
- Route of entry
- Dosage or airborne concentration
- Exposure duration or frequency
- Environmental conditions
- Controls

Chemical Laboratory Hazards



- **Chemical hazards**

  dusts, fumes, mists, vapors, gases

- **Physical hazards**

  fire, electrical, radiation, pressure vibration, temperatures, noise,

- **Ergonomic hazards**

  repetitive motion (pipetting), lifting, work areas (computers, instruments)

- **Biological hazards**

  pathogens, blood or body fluids

Chemical Laboratory Safety

Based on Industrial Hygiene Principles

- Anticipation
- Recognition
- Evaluation
- Control

chemical hazards
physical hazards
ergonomic hazards
biological hazards

Anticipate

- Potential problems and concerns

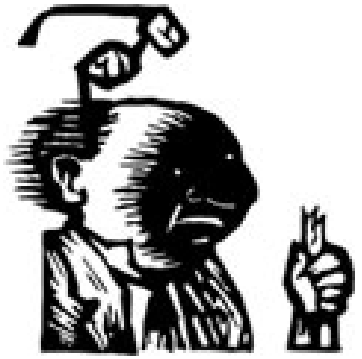
- Design a safe experiment first—
  - Don’t just design an experiment!

Anticipation

- **Plan Experiment in Advance**
  - **Outline proposed experiment**
    - **What chemicals? How much?**
    - **What equipment?**
  - **Acquire safety information**
    - **MSDS (Material Safety Data Sheet)**
    - **REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)**
    - **ICSCs (International Chemical Safety Cards)**
    - **Reference textbooks**
  - **Consult with Safety Office?**

Hazard Recognition & Evaluation

- **What are the anticipated risks?**
  - **Are the equipment & facilities adequate?**
    - **Is special equipment needed?**
  - **Are staff properly and sufficiently trained?**
    - **Who will do the experiment?**
    - **What kind of training do they need?**
  - **Can the experiment go wrong?**
    - **What would go wrong?**
    - **Is there a plan for this?**



Hazard Evaluation

- What are the potential or actual agents/exposures?
- When and where does the exposure occur?
- Which workers are exposed and how does the exposure occur?
- What is the evidence of exposure?
- What control measures are present, available, and effective?

Control

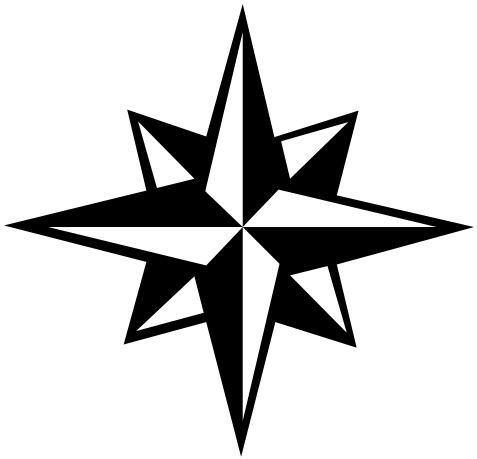
- How are the risks controlled?

- Administrative controls
- Engineering controls
  - enclosure / isolation
  - ventilation / hoods
- Personal Protective Equipment (PPE)
- Emergency Plan

Control Objectives

- ❑ **Maximize Containment**
- ❑ **Minimize Contamination**
- ❑ ***Redundancy is the Key***

Exposure Control



Source

Path

Receiver

Recognition

- **Types of lab hazards**
  - Chemical toxicity
  - Fire / explosion
  - Physical hazards
  - Biohazards
  - Radiation
  - Special substances

Types of Hazards in Chemical Laboratories

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Chemical Toxicity

Acute (short term, poisons, asthmagens)

cyanide

strychnine

Chronic (long term, carcinogens, reproductive)

vinyl chloride (liver cancer)

asbestos (mesotheloma, lung cancer)

thalidomide (developmental birth defects)

Chemical Toxicity

- **Toxicity depends on**
  - **concentration (dose)**
  - **frequency**
  - **duration**
  - **route of exposure**

"Dose makes the poison. All substances have the potential to harm."
Paracelsus ~1500 AD

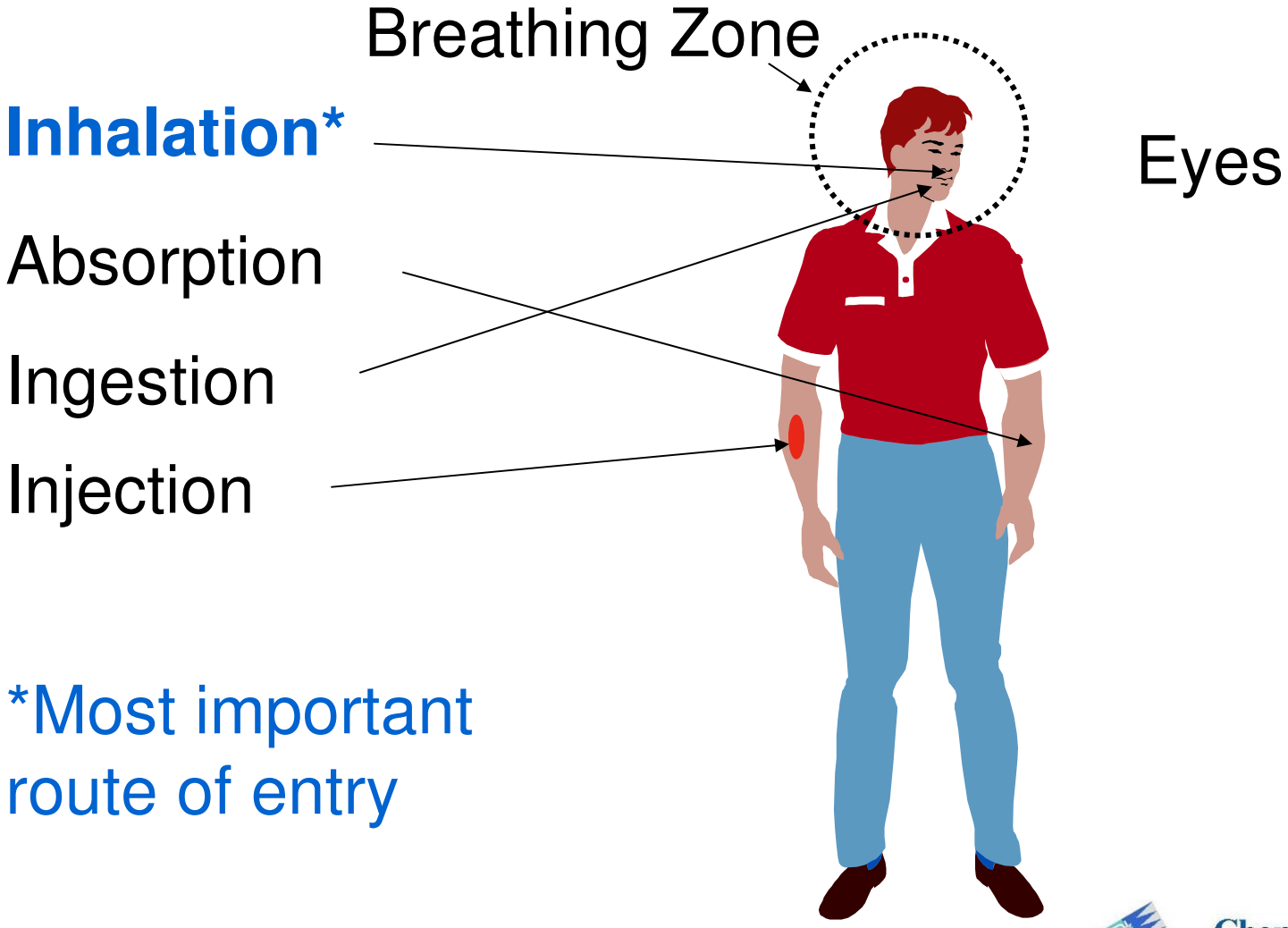
300 mg aspirin = safe

3000 mg aspirin = toxic

Particularly Hazardous Substances

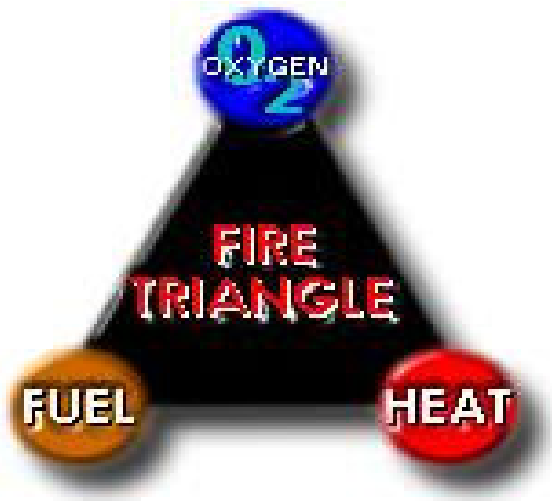
- Chemical Carcinogens
- Reproductive & Developmental Toxins
- Highly Toxic Chemicals

Routes of Exposure

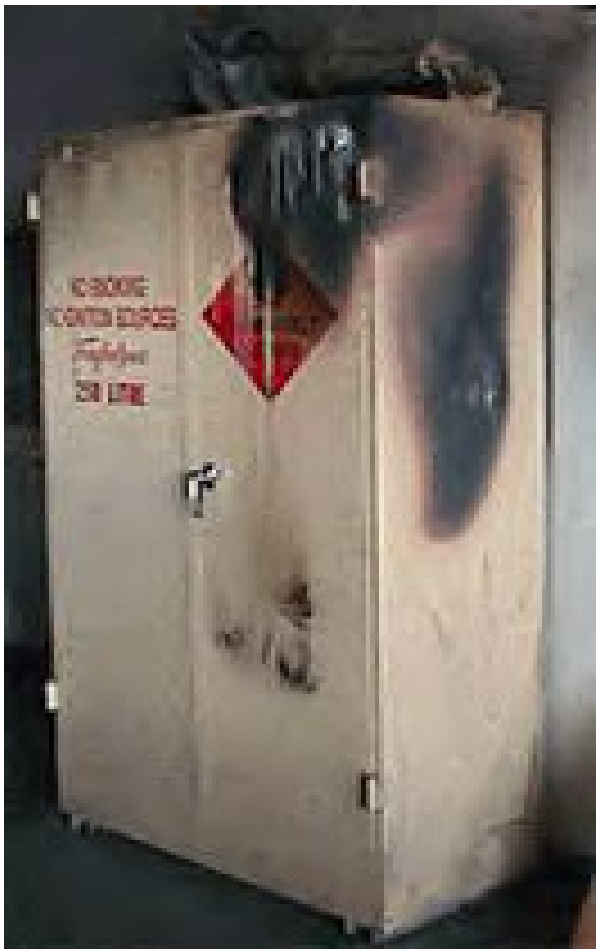


*Most important route of entry

Fire and Explosion Hazards



- **Flammable solvents**
- **Pyrophorics**
- **Spontaneous combustion**

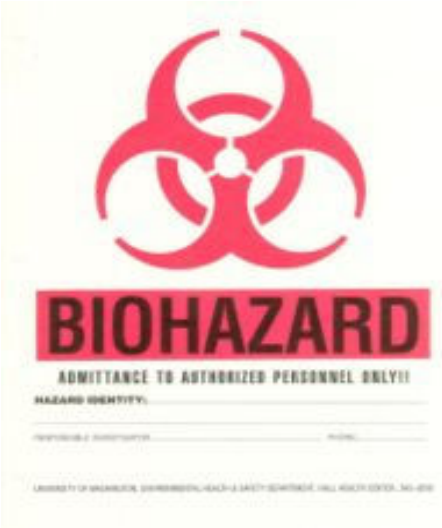


Physical and Ergonomic Hazards

- Moving unguarded parts, pinches
  - vacuum pump belts
- Broken glassware and sharps, cuts
- Pressure apparatus
- Vacuum containers
- Dewar flasks
- Cryogenics
- High voltage equipment
- Computer workstations
- Slips, trips & falls

BioHazards

- **Blood borne pathogens**
  - AIDS, HIV, Hepatitis, clinical chemistry labs
- **Recombinant DNA**
  - Genetic engineering, cloning
- **Work with animals**
  - Zoonosis, diseases from animals



Radiation Hazards

- **Ionizing Radiation**

  alpha , beta , gamma , X-rays, neutrons

- **Radioactive isotopes**

  tritium (H-3), carbon (C-14), sulfur (S-35),

  phosphorus (P-32/33), iodine (I-135)

Radiation Hazards

- ***Non-Ionizing Radiation***

Ultraviolet (UV spectrometers)

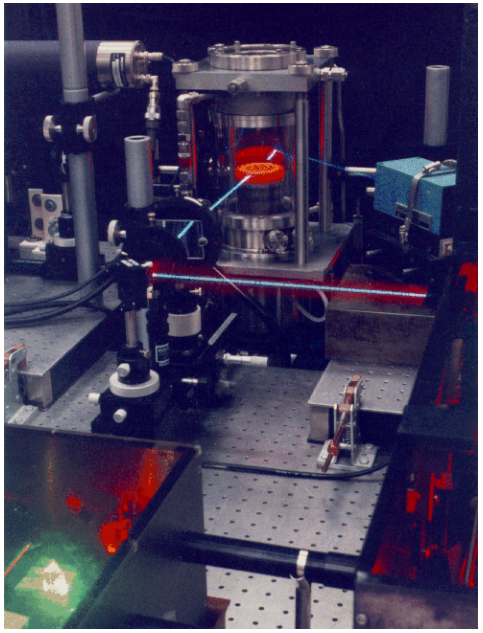
Magnetic (NMR, MRI)

Microwave

(Heart pacemaker hazard)

Lasers

(eye protection required)



Special Chemical Substances

- **Controlled Substances**

  regulated drugs, psychotropic (hallucinogenic) substances, heroin

- **Chemical Surety (Warfare) Agents**

  nerve gas, phosgene, riot control agents

Chemical Lab Safety: Administrative, Operational, and Engineering Controls

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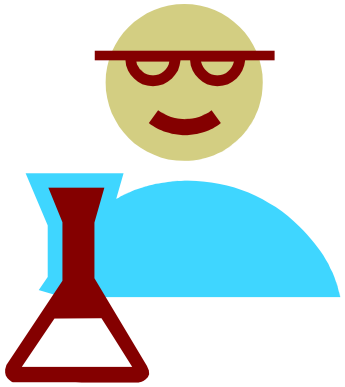
Evaluation & Control

- **Administrative practices**
  organizational policies
- **Operational practices**
  work practices
- **Engineering controls**
  Hardware (ventilation, barriers)



Administrative Practices: Lab Safety Policies

- Have organizational safety practices
  - Apply to everybody
  - Don't work alone after hours
  - Specify when eye protection & PPE is required
  - Specify operations that require hood use
  - No eating in labs
  - No mouth pipetting
  - No loose long hair or dangling attire
  - Label all chemical containers
- Have a Safety Manual

Administrative Practices: Lab Safety Policies

- Schedule routine, periodic maintenance and inspection of fume hoods
- Schedule routine, periodic maintenance of safety showers and eye wash stations
- Schedule routine, periodic maintenance of fire suppression/fighting equipment
- Post restricted areas with proper signs
  - radiation, biosafety, carcinogen, high voltage, lasers, authorized personnel only, etc.





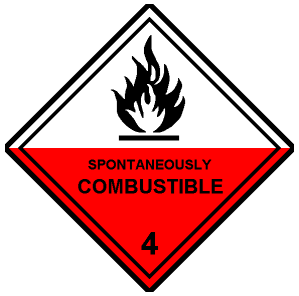
Operational Practices: Safe Laboratory Procedures

- Use hoods properly
  - 6” in from sash
  - in center of hood
  - work with hood sash at 12-18”
  - close sash when not in use
  - don’t use for storage

Operational Practices: Safe Laboratory Procedures

❖ Safely transport chemicals

- use container in a container concept
- label all containers
- inform driver of hazards
- provide contact names, phone numbers
- provide MSDS



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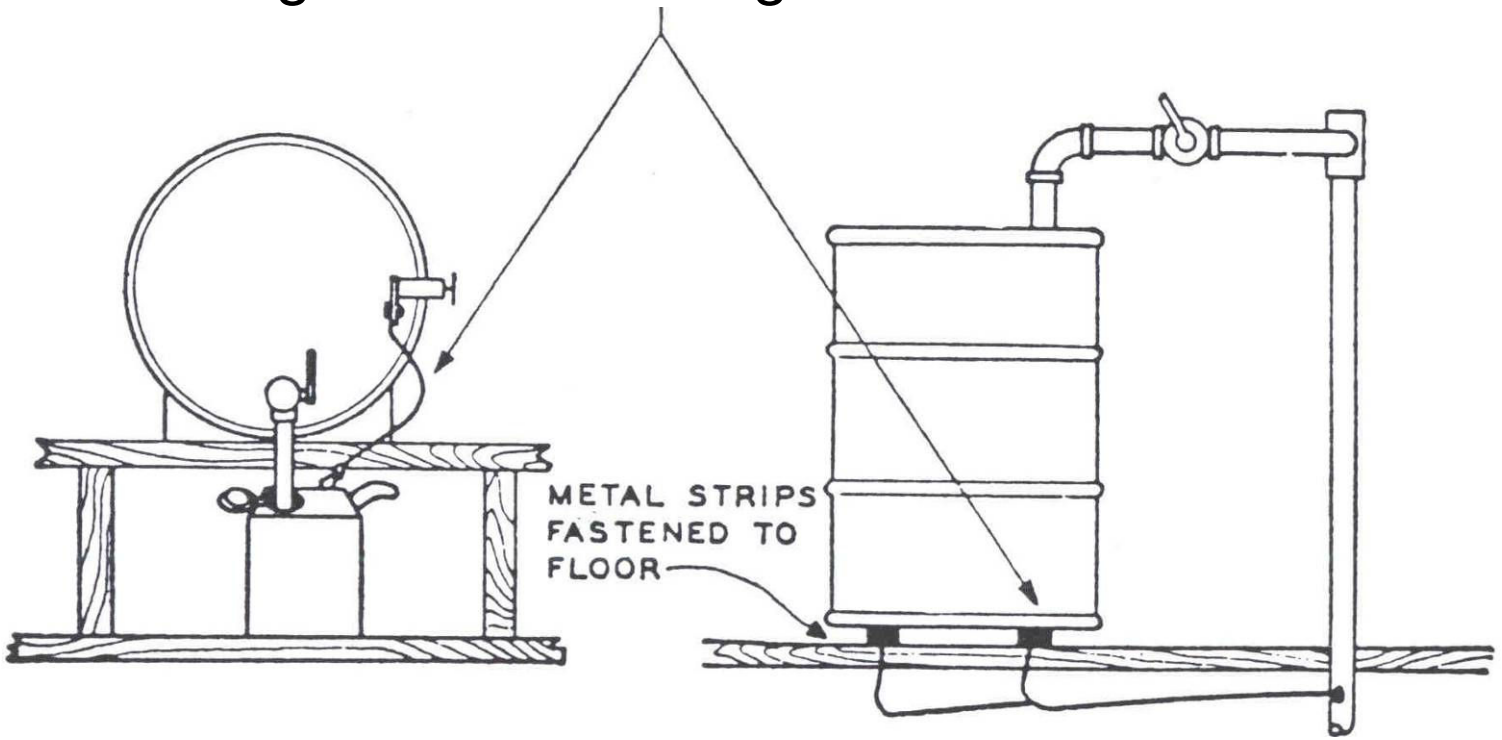
Operational Practices: Control of Static

Wire needed unless containers are already bonded together, or fill stem is always in metallic contact with receiving container during transfer



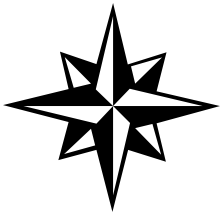
Operational Practices:
Safe Laboratory Procedures

❖ Housekeeping

- label all containers
- clean-up spills
- eliminate trip hazards
- proper storage

Engineering Controls: Laboratory Containment Principles

Concept



Source → **Path** → **Receiver**

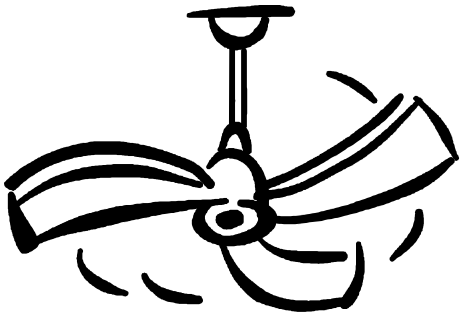
Control Used

Engineering Control → **Operational Practices** → **PPE**

Engineering Controls

1. **Change the process**
   - eliminate the hazard
2. **Substitution**
   - use non-hazardous substance instead of hazardous, such as toluene for benzene
3. **Isolate or enclose the process or worker**
   - use a barrier
4. **Ventilation**
   - dilution (general ventilation) - not good
   - local exhaust ventilation (LEV) - Preferred

Engineering Controls



Dilution / general ventilation

not good

Local exhaust ventilation

Preferred

Engineering Controls

Laboratory hoods and ventilation are the basis of engineering controls.
But they must be properly: functioning, maintained and used!

Engineering Controls: Local exhaust

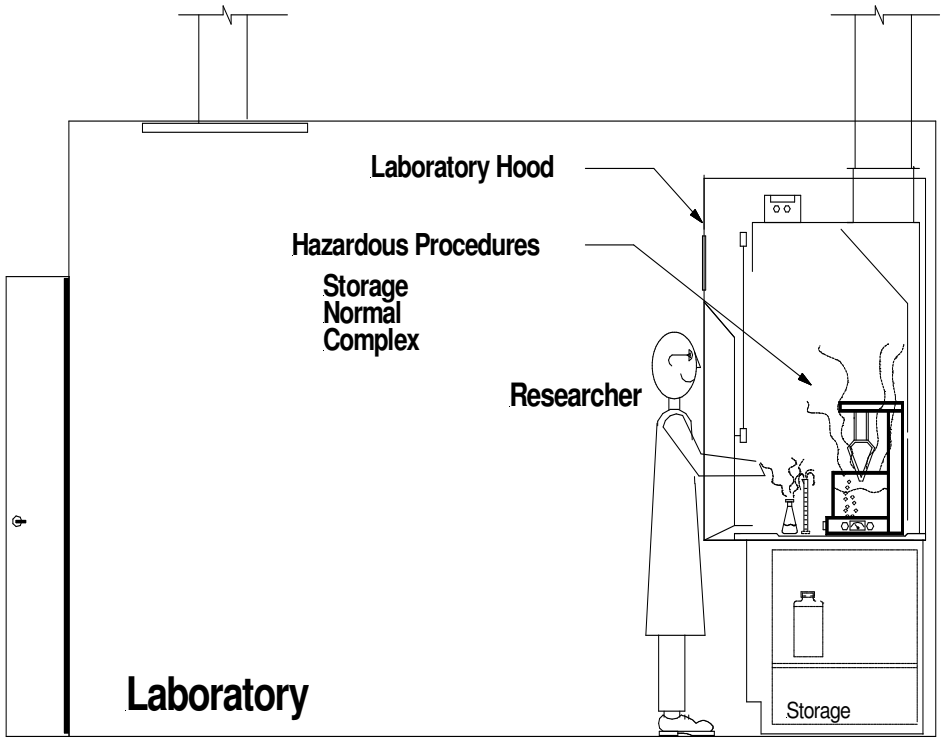
Local exhaust ventilation options include:

Snorkels

Vented enclosures

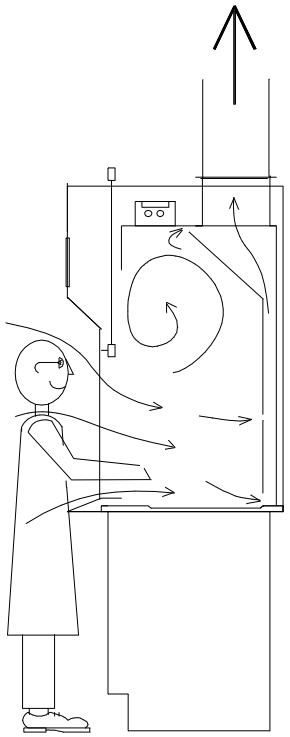
Proper Hood Use

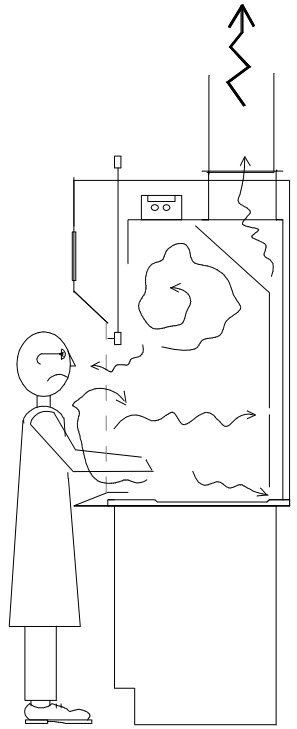
- Locate hood away from potential cross drafts
  - Diffusers, doors, windows, traffic
- Check hood is working properly before starting
- Check for containment
- Avoid clutter
- Do not use for storage
- Sash height at 12-18 “
- Work 6” in from sash
  - and in center



Hood Containment

- **Smoke candles and tubes can evaluate hoods**





Engineering Controls: Exhaust vents

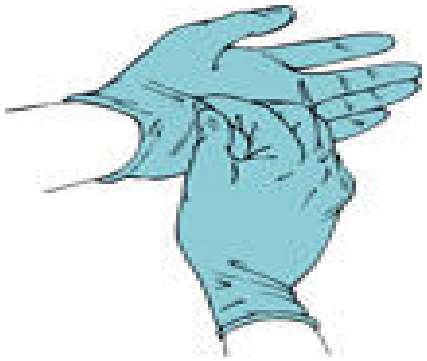
Hood exhaust should not be blocked or deflected downward, but should exhaust straight up

Engineering Controls: Exhaust vents

Avoid exhaust re-entrainment

Disperse emissions straight upward and downwind!

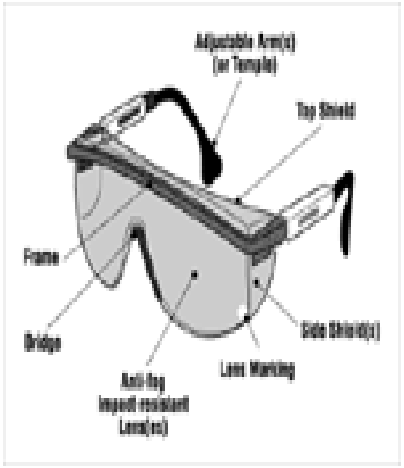
Engineering Controls:
Personal Protective Equipment (PPE)



PPE includes:
eye protection,
gloves,
laboratory coats. etc.,
respirators,
appropriate foot protection

Engineering Controls:
Personal Protective Equipment

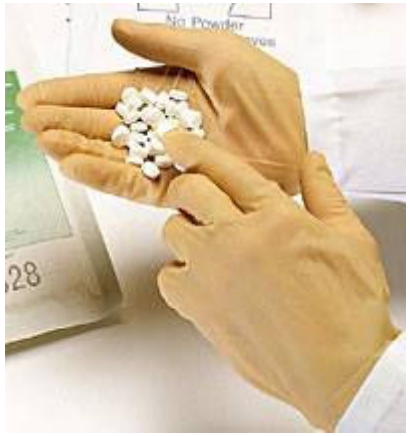
Eye protection specific to the hazard



Engineering Controls: Personal Protective Equipment

Gloves

must be chemical specific



Engineering Controls: Foot Protection

Safety shoes with steel toes are not necessary for laboratory work unless there is a serious risk from transporting or handling heavy objects.

however,
open toe shoes
should NOT be worn in labs